2010

Penn State University

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Mechanical Option

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[THESIS PROPOSAL]

Hotel Felix Located at Chicago, Illinois

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EXECUTIVE SUMMARY

Felix Hotel is a hotel space that is LEED Silver certified to be sustainable and one of the leading "green" hotels in Chicago. Thus, the mechanical system was designed very well to comply with many of the ASHRAE standards 62.1-2007 and 90.1-2007.

To take an even further step, two alternative mechanical system designs are going to be looked at for the upcoming semester. The first system is a combined heat and power system and the second is an integration of greywater heat recovery.

The goal of the analysis of using an alternative system is to create a more efficient building through mechanical systems. This can be accomplished by calculating annual energy consumption and utility costs of the proposed mechanical system and comparing it to the existing mechanical system to see if it is feasible. Additional cost analysis will be done to the new system to check the payback periods.

Several programs are going to be used for the purpose of this analysis. The first program is going to be Trane TRACE 700 for general enery loads and curves to compare to the existing mechanical system. The second program is going to be BCHP, a US DOE sponsored program developed by Oak Ridge Laboratory to, that calculates feasibility of CHP system in a commercial building.

MECHANICAL SYSTEM OVERVIEW

Felix hotel is a 16 story high building. It includes a basement level, lobby level, mezzanine level, 12 stories of hotel space, and a 13th floor mezzanine space for mechanical equipment. The total square footage of the building is 85, 700 SF and is located in the heart of downtown Chicago. The basement level is where most of the utility of the building is located such as mechanical room, electrical room, fire pump, gas meter, recycling, laundry, and data rooms. The lobby level has a bar, reception area, closet space, office spaces, and retail space connected to the street. The mezzanine level includes many additional conference rooms and offices for the employees of the hotel. It overlooks the lobby space from the second floor balcony and has a glass façade that looks out towards the street. The hotel levels each have 21 guest rooms with a small electrical room for panel boards and vending machine area with a linen chute. Floors two through twelve have identical floor layout.

AIRSIDE

The 7,500 CFM roof top unit is located on the roof of the hotel and uses 100% outside air that is either heated or cooled and brought into the hotel corridor spaces. There is a vertical mechanical shaft area that houses one supply duct and one return duct back into the roof top unit. The roof top unit uses direct expansion cooling and gas heating to heat and cool the outside air before introducing it into the building. The roof top unit will always be running regardless of occupancy. The unit has a heating capacity 650,000 BTU/Hr with a cooling capacity of 363,000 BTU/Hr.

The 8,000 CFM self contained packaged air conditioning unit is located in the basement and supplies air to the basement, first floor, and mezzanine floor via VAV terminal boxes. The AHU is factory built with water cooled compressors, filter sections, coils, and fans. The VAV terminal boxes uses electricity for its reheat coils and supply air to its desired setpoint. The unit has a cooling capacity of 363,000 BTU/Hr.

The water source heat pumps are installed in every hotel room that the guest can control to provide comfort and quality air to the room. Each water source heat pump is connected to a core loop pumping system that. Heat is added or rejected from the loop using two boilers and cooling tower that are all located on the roof. A heat exchange is connected to the cooling tower water

There is a gas fired unit heater located at the basement for the laundry room. It has a 620,000 BTU/hr output with a 6,500 CFM capacity connected just to the dryers.

WATERSIDE

The most important aspect of the waterside mechanical system is the cooling tower and boiler plants in the roof. The cooling tower will provide condenser water supply for the heat pump to operate for cooling when needed. The boiler plant is connected to the condenser water supply via 3-way mixing valve that will operate if the building automation system calls for heat to the hotel rooms. The cooling tower has a capacity of 480 GPM at 160 tons while there are two boilers both with 1,045,000 BTU/hr capacity at 63 GPM each.

There are two pumps that alternate bi-weekly to is connected to the cooling tower. The pumps has a capacity of 480GPM with a 15 HP motor. It will send out an alarm to the building automation system if one of the pumps fails.

There are two core water pumps connected to the water source heat pump loop with a 370GPM capacity with 15HP. Only one of the pumps will run every two weeks. However, if one pump is unable to maintain pressure the second pump will start. The building automation system will make sure both pump operates at same speed.

To provide hot water to the building, two natural gas fueled water heaters are located on the roof. Both boilers are rated at 84% efficiency with an output capacity of 1,554MBH. They are connected to two water storage tanks with a holding capacity of 400 gallons for a maximum of 800 gallons.

MECHANICAL DESIGN OBJECTIVES

For the renovation, the main focus for the building objective was to design it to be sustainable or "green" building. So, a lot of the mechanical system design was determined by the general requirements and procedures for compliance with certain LEED prerequisites and credits that is needed to obtain LEED Silver Certification.

Knowing that, the building HVAC system was designed in accordance with ASHRAE 90.1-2004 with mandatory provisions 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4 along with prescriptive requirements sections 5.5, 6.5, 7.5, and 9.5 or performance requirements Section 11.

Also, the indoor air quality control system of the building is designed in accordance with the standard ASHRAE 62.1-2004, ventilation for acceptable indoor air quality. The

ventilation rates were calculated to meet the ventilation rate procedures of ASHRAE 62.1-2004, sections 4 through 7.

PROPOSED ALTERNATIVE SYSTEMS

The current mechanical system design complies with ASHRAE standards and was able to obtain a LEED Silver certification with points from "Optimize Energy Performance – HVAC". This shows that the current system has already been designed to be efficient and meet the needs of the building.

However, other systems will be explored to help reduce overall energy usage throughout the building and lower utility costs and make the building more efficient. Payback periods for these systems will be also explored to conclude if the system is really viable or not in Chicago, Illinois.

COMBINED HEAT AND POWER (CHP)

Combined Heat and Power (CHP) is an alternative system that will be explored for possible energy reduction, utility cost reduction, and low payback period. CHP is a method of generating both electricity and thermal energy at the site instead of buying electricity from the grid. separate heating power (SHP) is what the hotel was utilizing

where it bought electricity from the Exelon Corporation to power the mechanical systems and boilers and cooling tower.

Felix hotel can be a good candidate for CHP technology because it has a high electrical demand as well as thermal demand all around the year. From technical assignment 2, we saw that the boiler was the biggest energy consumer in the mechanical system and we can potentially produce all the thermal energy required through one single prime mover that produces both electricity and thermal.

A combined heat and power plant could potentially have many benefits over a separate heating and power. One major benefit of combined heat and power is that the system will use much less fuel overall. CHP systems have one prime mover that produces electricity and the waste heat is then captured to be used for thermal load using a heat exchanger or a steam turbine. Because we take the boiler out of the equation compared to a SHP system, less fuel is utilized. Also, there is no loss in electricity transmission through power lines to the building because we don't have to buy the electricity from the grid.

Now, adding a CHP system will result in a high initial cost because the prime mover must be purchased on site and the accessories involved in the system. Also, maintenance cost must not be forgotten in keeping the CHP system operable. Additional work is required that we would not need in a conventional SHP system.

This could also mean that we could get rid of certain mechanical equipments. The gas fired unit heat for basement laundry can be removed along with downsizing water heaters and boilers for domestic water and water source heat pumps because the thermal energy from the prime mover can cover the system.

By doing a CHP analysis, the feasibility of the system will be found by choosing the correct type of prime mover and comparing the spark gap between the fuel that would be used for the system and electricity. There are many prime movers that could work but

reciprocating internal combustion engine and natural gas micro turbine will be considered for this building.

GREYWATER HEAT RECOVERY

Greywater heat recovery is a very interesting topic because there is not many applications of the system in the United States currently. Greywater is any household wastewater such as kitchen sinks, showers, bathroom tubs, and bathroom sinks. Blackwater such as toilets and sewage are not part of the recovery process because of health concerns.

Greywater heat recovery uses the principle of capturing some of the heat in drain-water, allowing it to be reused by incoming water. This can be done because it is said that 80-90 percent of energy used to heat water for domestic use goes down the drain.

A high rise hotel with many shower heads in the building can be a very good candidate for this system as it can reduce energy costs of water heating because the water heater can be sized significantly smaller. Another benefit of this system is it can increase the effective availability of hot water when it is needed the most, such as in the morning or night.

TOOLS FOR ANALYSIS

For the purpose of this analysis, either Trane TRACE will be used for the purpose of energy modeling and comparison with the existing mechanical system. Trane TRACE was used for Technical Assignment 2 so the results would be in the same format thus allowing us to compare the benefits of energy consumption, utility cost, and emission information.

Another program that will be explored is BCHP. BCHP is a programmed designed to evaluate the feasibility of a CHP system in commercial buildings. It is a program that is sponsored by the US Department of Energy's Distributed Energy Program. The program is still in the early stages in terms of development and functionality but it can still fulfill the purpose of general calculating electrical loads and emulate monthly and annual utility costs.

BREADTH TOPICS

ACOUSTICAL

One concern for CHP technology is the noise that it can generate from the prime mover. Because the hotel is located in the heart of downtown, proper action must be taken to ensure the noise level is not too loud during operating hours. If an analysis is done and found that the system is too noisy, construction must be done around the CHP system to reduce the noise level by selecting proper material to reduce the noise level. Acoustical studies will also be done to the mechanical room in the basement to make sure it is under acceptable noise levels.

ELECTRICAL

Introducing a CHP system can have a big impact on the electrical power for the building. The building will need an adequate emergency backup generator in case the CHP system fails to run because there would be no other source of electricity unless the building is tied into the grid for emergency situations.

PROPOSED SPRING 2010 SCHEDULE

	1/28/2011				2/18/2011		3/4/2011			3/25/2011			
1/10	1/17	1/24	1/31	2/7	2/14	2/21	2/28	3/7	3/14	3/21	3/28	4/4	4/11
Research Proposed Systems													
Feasability of Greywater Recovery System													
Select New Mechanical Equipment													
Obtain Equipment Cost													
Work on Electrical Breadth													
Work on Acoustical Breadth													
Create TRACE model													
Analyze Energy consumption													
Finish Calculations													
Prepare Presentation													
Presentation													

REFERENCES

Technical Assignment 1 / 2 / 3

Oak Ridge National Laboratory : BCHP Screening Tool Program
(http://www.coolingheatingpower.org/about/bchp-screening-tool.php)